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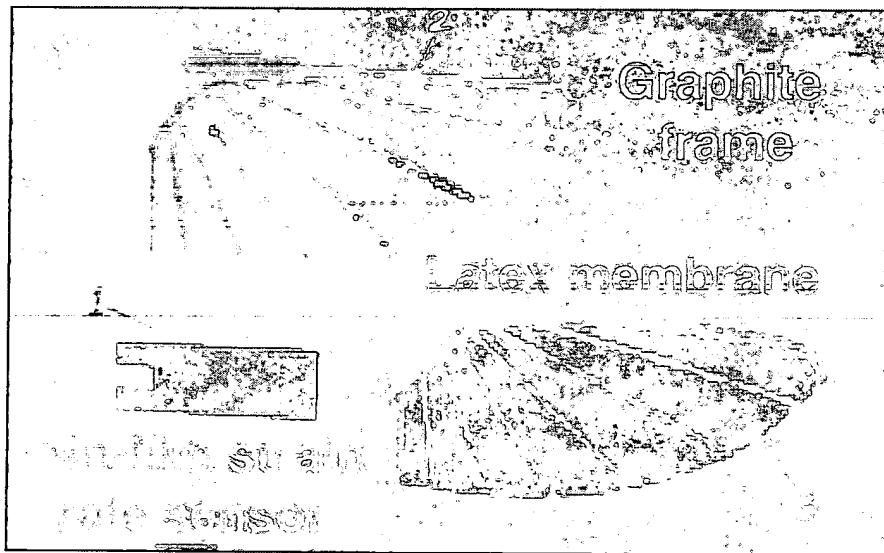


FIG 1. Image of strain-rate-sensing flexible wing components.

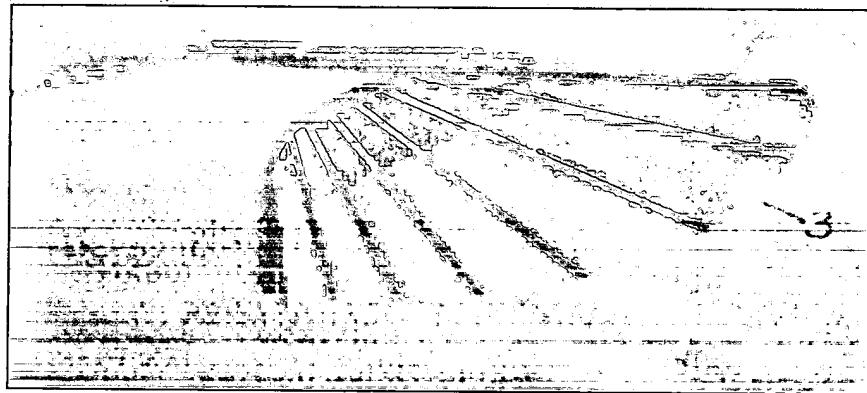


FIG 2. Image of completed strain-rate-sensing wing assembly.

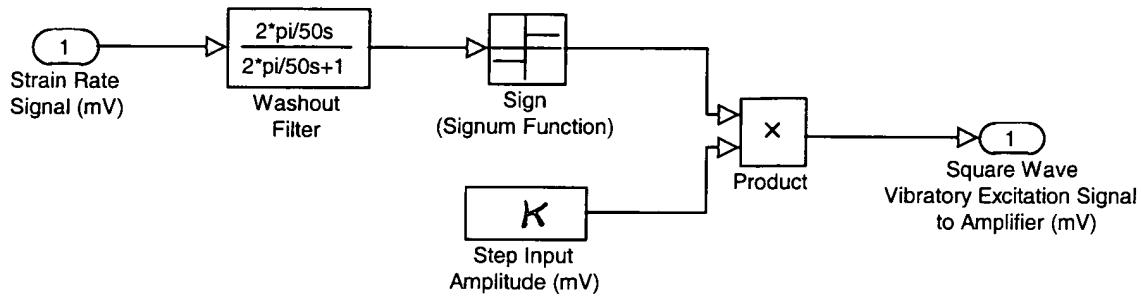


FIG 3. Simple algorithm for resonant tuning circuit using strain rate feedback to drive vibratory excitation actuator.

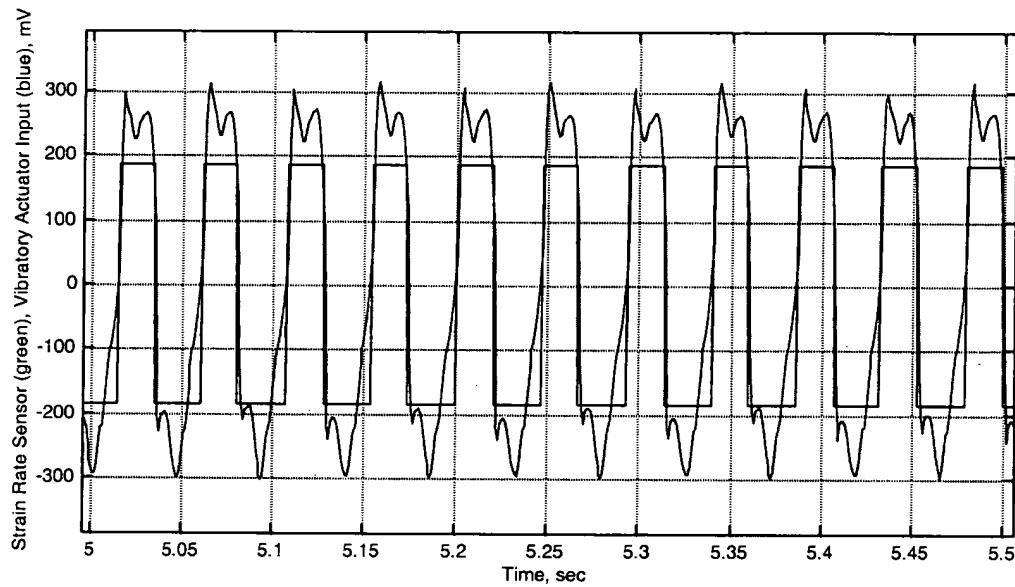


FIG 4. Example data from closed-loop operation of resonant flapping laboratory apparatus showing strain rate sensor output and vibratory actuator input (square wave).

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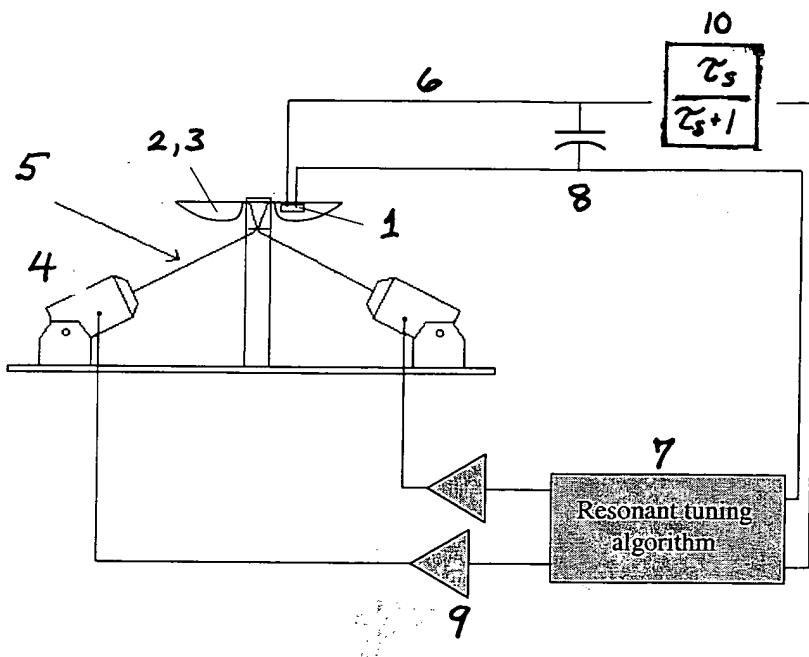


FIG 5. Flowchart showing arrangement of innovation components.

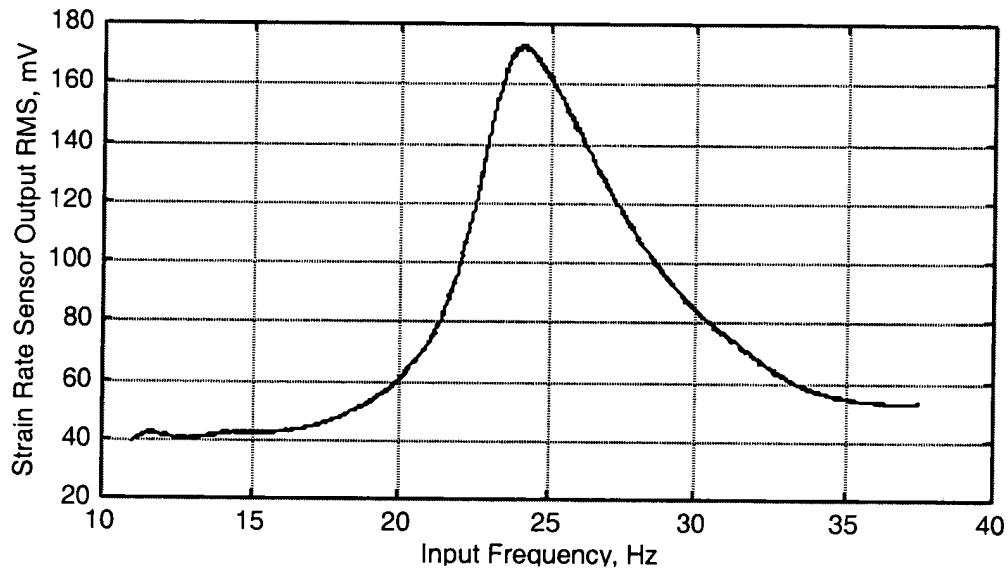


FIG 6. Frequency sweep of input to resonant ornithopter apparatus showing RMS (root-mean-square) output of the strain rate sensor (with maximum output at the fundamental resonant frequency of the flexible wing structure - 24 Hz).

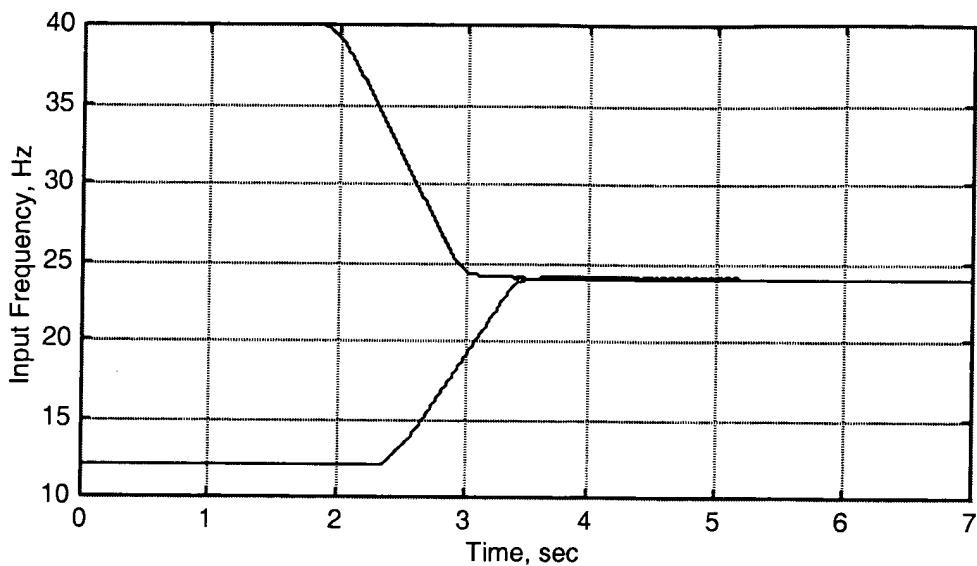


FIG 7. Time-histories of frequency of actuator excitation showing convergence to resonant frequency when the closed-loop system is activated.

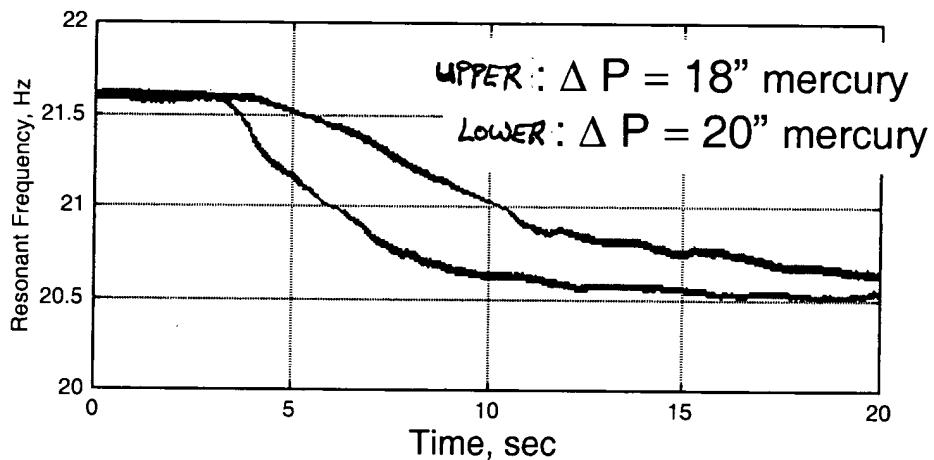


FIG 8. Time histories showing the change in resonant frequency of the closed-loop system subjected to pressure changes of approximately 18" and 20" of mercury